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THE BIOLOGICAL BASIS OF INDIVIDUALITY[1]

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WE apply the term "individual" to a living organism to emphasize the distinctive, unique features which such an organism possesses. In individual human beings we note their appearance, motor reactions and psychical expressions and certain inherited or acquired structural or functional peculiarities, such as nevi, allergies. There are in addition two very fine modes of distinguishing one human individual from every other one. These are the individual scents attaching to different areas of the body, representing in their totality a characteristic by means of which a dog can distinguish one individual from every other one; and there are the patterns of the skin ridges in the palms of the hands and in the fingers, which are now so commonly used for identification. Recently it has been stated that also the changes in electrical potential in certain areas of the brain are characteristic of an individual and are relatively constant in him (Hallowell Davis).

All these individual characteristics which we have mentioned so far are localized in certain areas of the organism, in special organs or tissues; they are either structural or functional peculiarities of these tissues and organs. If we consider the individual as a mosaic of many tissues and organs, each one functioning and metabolizing in its own peculiar way, we may consider this mosaic of separate parts as the biological basis of

[1] Read before the joint meeting of the Federation of American Societies for Experimental Biology in Memphis on April 22, 1937, and representing the abridged fourth annual Arno B. Luckhardt lecture of Phi Beta Pi of the University of Chicago Medical School, delivered at the Billings Hospital of the University of Chicago on March 30, 1937. The recent investigations reported were carried out with the aid of a grant from the International Cancer Research Foundation. References to the literature up to the year 1930 may be found in an article by the author on "Transplantation and Individuality" in *Physiological Reviews*, 10: 577, 1930.

individuality, including the psychical characteristics, and in order to understand individuality in this sense we would have to study the peculiarities of the units composing this mosaic in each individual; also the nervous system and the hormone system, which serve as means of communication between the various parts of the body, represent special organs or products of organs and are therefore parts of the mosaic. They are the properties of organisms, the so-called factors, which are analyzed as to their genetic basis by means of hybridizations according to the Mendelian methods.

There is, however, in addition to this mosaic basis of individuality, another basis. There are properties which are not restricted to parts of the organism, but which are common to all, or almost all parts of an organism, which, although not visible, bind them together, make them into a unit and differentiate an individual from every other individual, a species, genus, order, class of organisms, from every other species, genus, order and class. There is inherent in every higher individual organism something which differentiates him from every other individual, which can be discovered by observing the reactions of certain cells and tissues belonging to one individual towards the tissues and cells of another individual of the same species. They act as if there was something in common to all parts of one organism which differs from the analogous characteristics of all the parts in a different organism of the same species. And not only do these cells recognize the different individuals as such, they do more than that, they recognize, to speak in a metaphorical way, the degree of difference between two individuals as based on their genetic constitution.

In a provisional manner we may designate this common characteristic distinguishing one individual from another as his individuality differential; it is common to the various organs of an individual in contrast to the organ differentials which differentiate from one another the different organs, such as liver, kidney, thyroid, cartilage, in the same individual. In the same way there are characteristics common to all members of a species, genus, order and class, and these may be designated in their totality as organismal differentials, among which the individuality differential is the highest and finest one.

There are two principal methods by means of which these organismal differentials can be analyzed, namely, (1) by various types of transplantation and (2) by serological methods. The transplantation and serological methods are not equally well adapted to the analysis of organismal differentials; each has its own sphere in which it can be applied to the greatest advantage. While the serological tests are especially useful in the analysis of the differentials of wider groups of animals, such as species, genera, orders and classes, transplantation experiments are best suited for the analysis of individuality differentials.

We are concerned principally with the study of the individuality differential, and here the basic experiment is the following: We transplant various organs or tissues from one animal, *e.g.*, a guinea pig, into two other guinea pigs not directly related to each other or to the first guinea pig from which the tissues were taken; we call this homoiotransplantation. It is seen that the reactions of the hosts of the multiple grafts towards the latter differ in intensity in accordance with the degree of the genetic relationship between host and donor, but the host behaves in approximately the same way towards the various tissues from the same donor. In one animal the reactions are severe to all the tissues, in the other one they may be very light. These reactions consist in the activity of the lymphocytes, the connective tissue cells and blood vessels of the host towards the grafts; in addition, certain more sensitive tissues are also influenced by the degree of their compatibility with certain constituents of the blood of the host, and the degree of sensitiveness again depends upon the genetic relationship between host and transplant. The reactions of these different types of cells are not equally delicate. It is the lymphocytes which sense or recognize the finest degrees of similarity or difference in the constitution of the individuality differentials between host and transplant. The distinctive reaction of the connective tissue cells takes place if there is a slightly greater difference between these differentials. I said that all the tissues from the same donor elicit the same intensity of reaction on the part of the same host. This is true in a relative but not in an absolute sense. Different tissues have an unequal power to call forth these reactions; thus, for instance, thyroid gland usually induces a stronger reaction than cartilage and perichondrium. This is evidently due to the fact that a certain substance responsible for the reaction, the individuality differential, is given off in sufficient quantities more readily by thyroid than by cartilage, which latter has a more inert metabolism. However, if we grant these differences between different tissues and organs, after all the genetic relationship between host and transplant determines the intensity of the reaction in the tissues possessing individuality differentials.

There is a second experiment which brings out the meaning of the individuality differential. We can transplant various kinds of tissues and organ pieces into the same animal from which they were taken and to which, therefore, they belonged. This is called autotransplantation. We then find that lymphocytes are practically lacking around the graft; connective cells are attracted in only a moderate number and instead of producing dense fibrous tissue, which is

characteristic of their reaction against a strange individuality differential, they form a loose embryonal stroma around the transplanted cells. The blood vessel supply is rich, and in the course of a relatively short time the transplant assumes about the condition of the normal tissue or organ in the host. All tissues from the same organism behave in this respect, in principle, in the same way, except that some tissues can withstand the injury connected with the process of transplantation much better than others. We may then conclude that it is not the organ differentials which determine these injurious reactions of the host cells towards the grafts, but the individuality differentials. The chemical constitution of liver and kidney is very different, but this difference has no effect on the host cells—they react in about the same way towards liver and kidney, provided these tissues possess the same individuality differential; however, a slight difference in the chemical constitution of the individuality differential sets these reactions in motion; and it makes little difference whether this strange individuality differential is attached to the kidney, liver, skin, cartilage, uterus or thyroid organ differential. The various organ differentials all behave in about the same way.

This, then, is the first important fact: The host cells recognize in a very subtle way differences in individuality differentials. But they can do more than this; as I stated before, they are able to recognize the degree of difference and to react accordingly. Thus, when a piece of tissue from brother to brother is transplanted—we call this syngenesio-transplantation—the cells of the one who functions as host are not as much stimulated or excited by the presence of a tissue which is so closely related to his own as by the tissues from a non-related individual, the individuality differentials being more similar in this case. However, brothers and sisters may be genetically similar to each other to very different degrees and therefore in some instances the reaction against such a tissue may be about the same as against that of a stranger; but usually the reactions on the part of the lymphocytes are delayed and the reaction of the connective tissue may be diminished.

On the other hand, if a piece of tissue is transplanted which is genetically further removed, which has been a part of an individual belonging to a different species (heterotransplantation), the reactions are more severe. In this instance the body fluids of the host are so different from those to which the tissues of the transplant are adapted that they exert a strongly injurious effect and kill the graft in a relatively short time; the length of time in which this can be accomplished depends, among other factors, upon the degree of resistance of the particular tissue. The reaction of the connective tissue of the host is very strong in these cases of heterotransplantation; besides, it is the polymorphonuclear leucocytes which are attracted first, rather than the lymphocytes, indicating the presence of a substance which acts as a stronger poison, a heterotoxin. The reaction of the lymphocytes is the test for the presence of a milder toxin, namely, homoio- or syngenesiotoxin. However, at a later period when the acutely acting toxins have been largely absorbed, lymphocytes may also be attracted and collect in large masses around tissues derived from a strange species. We see, then, that the host cells not only recognize a strange organismal differential, but they also distinguish between different degrees of relationship or strangeness. But there is a limit to this power of discrimination. If a certain threshold of strangeness has been reached, the reaction is maximal and can not be much increased if the tissues from individuals belonging to still further removed classes are used. In this case serological tests are better able to grade differences. The cellular reactions with which we have to deal in transplantation are comparable to a very sensitive balance which indicates small fractions of a milligram and which can not be used for the detection of differences which are measured by pounds.

Certain experiments show that the similarity or difference between two individuality differentials corresponds to the similarity or difference in the composition of the gene sets in the host and donor, and that the host cells respond, so to speak, to genes which are strange to them. In reality, however, it is not the genes as such to which the host cells react, but the organismal differentials which develop in accordance with the gene sets.

That it is the similarity or difference in the gene sets in two individuals which determines their similarity and difference in reaction is also indicated by the fact that if, through close inbreeding, we render their gene composition more similar, the individuality differentials correspondingly become more and more similar in the course of inbreeding. But it has been found very difficult to produce identity of the organismal differentials in others than brothers, although this can probably be accomplished in the end. However, it seems that different species of closely inbred animals differ in respect to the readiness with which this stage is reached and the transplantation method can therefore be applied in order to test to what degree the gene composition in a closely inbred family or strain has become similar or, expressed differently, the degree of homozygosity which has been reached in such a strain.

There are indications that during embryonal development also the individuality differential develops from a precursor substance; it is certain that at least the mechanism which makes its effects manifest undergoes such a development. Even in very young guinea

pigs, before the age of sexual maturity, these mechanisms of defense against a strange individuality differential are not yet fully developed, as is indicated by transplantation experiments of adult tissues. The connective tissue reaction is diminished in intensity and the lymphocytes have therefore a better chance to become active in these young animals.

As to the number of genes which enter into the precursors of the individuality differentials no definite statement can be made. However, considering the difficulty in eradicating reactions against other than autotransplants, even in individuals belonging to strains closely inbred through a considerable number of generations, and considering the improbability of ever obtaining after homoiotransplantations in non-inbred strains an autogenous reaction, also in view of the fact that the reactions are so very finely graded and that a homoio- or syngenesio-reaction, after transplantation of a piece of tissue belonging to another individual, may appear as late as several months following transplantation, it is very likely that the number of genes entering into the composition of the individuality differential is great and that perhaps all the genes participate, although different ones possibly to a different degree. Both organismal differentials and organ and tissue differentials depend entirely, or to a large extent, on the constitution of chromosomes and genes; but the genes and combination of genes which preponderate as determiners of these two types of differentials are evidently not the same and there are indications that it is certain gene sets rather than individual genes which represent the precursors of organismal differentials.

Not every substance present in or produced by tissues possesses an individuality differential. Many less complex substances, degeneration or decomposition products of tissues, such as keratin, fibers of the eye lens, many hormones, vitamins, do not possess individuality differentials; certain of these may, however, possess some of the coarser organismal differentials.

We see, then, that tissues give off substances which differ in their effects in accordance with the relationship of the tissues to the host organism. In their own natural habitat these substances are of an autogenous character and do not incite any abnormal reaction. In accordance with the genetic strangeness existing between transplant and host, these substances assume the character of toxic substances, which call forth abnormal reactions in the host. In near relatives these substances—the organismal differentials—act as syngenesiotoxins; in a strange individual of the same species they act as homoiotoxins and in a different species as heterotoxins. The chemical nature of the latter is distinct from that of the syngenesio- and homoiotoxins.

Furthermore, these substances, the organismal differentials, diffuse not only into the area directly surrounding the transplanted piece, but they also enter the circulation and are carried by the blood or lymph to further distant organs. This may be concluded from the fact that transplantation of a normal piece of grafted tissue induces changes in the proportion of the circulating blood cells, which are parallel to the degree of relationship or strangeness between host and transplant, and which depend therefore on the nature of the organismal differentials of host and graft. These changes have recently been studied and are being studied at the present time by Mr. H. T. Blumenthal in our laboratory. I may mention some of the results obtained by him so far: After homoiotransplantation of a lobe of thyroid gland, of pieces of liver or kidney from guinea pigs to other non-related guinea pigs or from rats to rats or pigeons to pigeons, the count of the lymphocytes rises about five to seven days after transplantation, by approximately 15 per cent. or somewhat more, and after having reached the maximum it begins to fall again. After transplantation of cartilage, however, the rise is lacking entirely or almost entirely, because the amount of homoiodifferential given off is apparently insufficient to reach the threshold necessary for a rise. After syngenesiotransplantation the increase in lymphocytes begins, on the average, at a somewhat later date and remains lower. After heterotransplantation it is the polymorphonuclear leucocytes which show an increase in the general circulation; they then fall to the normal level, and this phase is followed by a second phase in which the lymphocytes rise; after a few days this latter rise is likewise followed by a fall. As far as we can judge, these changes in the number and character of the blood cells are specific. After autotransplantation of tissues these characteristic changes in the composition of the blood cells do not occur, but only some slight, non-specific variations may take place, in some instances, in the first few days following the operation. Neither does introduction of inert foreign bodies, such as threads and agar, cause changes comparable to those following syngenesio-, homoio- or heterotransplantation. These effects produced by transplants on the lymphocytes and polymorphonuclear leucocytes, circulating in the blood, are closely parallel to the effects which the transplants exert locally on the lymphocytes and polymorphonuclear leucocytes.

We see thus that substances corresponding to the individuality and species differentials not only diffuse from the transplanted tissues into the neighboring areas, but also reach the blood and exert their effects in distant parts. These substances thus resemble hormones in their action.

If, then, we may consider it an established fact that

when tissues are transplanted from one to another individual of the same species, even to nearly related individuals such as brother and sister, substances are given off by the tissue which call forth noticeable reactions on the part of the host cells, might it not be possible or even probable that such substances, acting on nearby tissues as contact substances or on further distant tissues as hormones, are also given off in the animal's own organism, but that here, instead of acting as disturbers of the tissue equilibrium, on the contrary, they function as instruments by means of which the tissue equilibrium is maintained and regulated in such a manner that it is best adapted to the normal cooperation of the various tissues in the interest of the entire organism and thus to the normal functioning of the organism as a whole? Such substances, representing the individuality differentials, if discharged into their own organism, may then be designated as autogenous substances. We have seen that after autotransplantation the connective tissue cells and blood vessels of the host react towards the transplant in a way that is most conducive to the normal metabolism, structure and function of the graft and that lymphocytes are practically absent. May we not attribute these beneficial reactions to the controlling influences of autogenous substances given off by the transplanted tissues, contrasting with the syngenesio-, homoio- and heterotoxins which are given off by strange tissues? Correspondingly, if two tissues, possessing two different individuality differentials, have been made to adjoin each other, signs of disharmony develop, which are partly or largely due to the action of disharmonious individuality differentials. This applies for instance to homoiogenous skin transplants. Conversely, may we not assume that, since the epithelial cells in the normal skin remain at rest, this is due, at least to a certain extent, to the action of the autogenous substances which keep the neighboring epithelial cells as well as the underlying connective tissue and lymphocytes quiescent?

There exists, then, a mutual adaptation to one another of tissues bearing the same organismal differential, and there exists also a mutual adaptation between the blood plasma and the various tissues belonging to the same individual. It is these harmonious interactions which make the unity of the organism possible and which are perhaps the most characteristic feature of the living organism as an individual. But not only are the substances characteristic of each individual different from those characterizing any other individual, and in this sense specific; there exists, besides, a second type of specificity, which may be designated as specific adaptation. By specific adaptation we mean that it is the individuality, species, order or class differential, in general the organismal differentials, attached to the various tissues or to substances derived from these tissues, which determine how suitable and effective the interactions between these tissues and substances are. If the respective organismal differentials are the same in the tissues or substances the interaction is most effective. This applies, for instance, to the interaction between tissue extracts, blood plasma and blood serum. The character of the organismal differentials attaching to these various substances determines how effective the coagulating power of the extract will be, and how effective also the inhibiting action of the blood serum will be.

We may then distinguish two types of adaptation within the organism. The first one is well recognized; it is represented by the normal physiological interaction of various organs and of parts of organs. It is based on transmission of stimuli or inhibitions through the nervous system, through hormones and through certain other mechanisms. This is largely independent of organismal differentials. The second one is the adaptation based on the identity of the organismal differentials. But in addition a number of chemical interactions in the organism, of which only one example has been mentioned, depend specifically on the character of the organismal differentials which are carried by the interacting substances.

The organism is then a harmonious whole, in which not only the organ functions are adapted to one another, but in which also all the various tissues, which apparently are not functionally related, are specifically adapted to one another, owing to the nature of their organismal differentials. This latter adaptation above all is what characterizes the individual. Such a harmonious relationship must be based on resemblances or identities in certain chemical structures of the most important and complex substances which enter into the building of the organism, especially substances of a protein nature. Thus it has been established that the hemoglobins and hemocyanins derived from various species or still larger groups of animals are the most nearly identical in structure in the nearest related animals, and are the more different in structure the further distant the species are. We may assume that the same chemical gradation in the structure of the organism must go still further, not only each species, but each individual possessing its chemical characteristics, which differ from those possessed by every other individual of the same species.

We believe, then, the conclusion is justified that in certain respects these chemical differentials of organisms are the most characteristic features of individuals as such, and that in their totality and interaction they constitute the most essential biological basis of individuality.

SCIENTIFIC EVENTS

THE JANE COFFIN CHILDS MEMORIAL FUND FOR MEDICAL RESEARCH

THE establishment of the Jane Coffin Childs Memorial Fund for Medical Research in memory of the late Mrs. Starling W. Childs was announced at the alumni luncheon at the two hundred and thirty-sixth commencement of Yale University. The name of the donor was not made public, but it is reported in the daily press that the endowment was set up by Starling W. Childs, New York investment broker. Under the deed of gift the foundation, which is expected to cooperate closely with the Yale Medical School, will be administered by a board of managers advised by a board of scientific advisers. The members of the board will be:

Dr. Stanhope Bayne-Jones, dean of the Yale Medical School, a bacteriologist.

Dr. Rudolph J. Anderson, professor of chemistry at Yale, who has done extensive research into the chemistry of the tuberculosis germ.

Dr. Ross G. Harrison, professor of biology at Yale and director of the Osborn Zoological Laboratory in the university.

Dr. Peyton Rous, of the Rockefeller Institute for Medical Research.

Dr. Milton C. Winternitz, formerly dean of the Yale Medical School and now Anthony N. Brady professor of pathology at Yale.

The resources of the foundation, said to be in the neighborhood of $10,000,000, will be devoted primarily to research into the causes and origins of cancer. It is provided that when in the judgment of the board of managers the causes and origins of the disease had been sufficiently determined, the fund "may thereafter on the advice of the board of scientific advisers" be devoted to research into "some other unsolved problems of medicine" or of "some other field of science."

In announcing the gift, Dr. Angell, retiring president of the university, spoke as follows:

The generous gifts pledged for the endowment of the Jane Coffin Childs Memorial Fund places the university and our alumni under an enduring debt of gratitude to the donors.

Our abiding appreciation of their great gifts for this purpose will be shared by the world at large because of the vision and imagination shown by them in planning for the administration of this foundation, to make sure that it will benefit not merely Yale and our own community of New Haven, but that it will also, through Yale, help advance the cause of scientific research elsewhere and thus, indeed, render signal service to mankind.

I only wish that I could put into adequate words half of what I would like to say of our happiness that Yale has been entrusted with the means to benefit from what is, I think, the greatest opportunity ever given to any of our universities.

I count myself fortunate in that this has come to us while I am still Yale's president, so that I may have the honor to voice her gratitude and assure the donors of her determination to prove worthy of their confidence.

THE WORK OF THE NEW YORK ZOOLOGICAL SOCIETY

THE forty-third spring meeting of the Board of Trustees of the New York Zoological Society, following the luncheon given in the Administration Building at the Bronx Park, occurred on May 13.

It will be recalled that this society, in addition to managing the Zoological Gardens, operates the Aquarium at Battery Park; is responsible for the series of marine expeditions under the direction of Dr. William Beebe and is an active force in conservation.

The meeting was presided over by Madison Grant, president, whose subsequent death on May 30 completed forty-two years of service as an officer of the society.

The trustees present were Messrs. W. Redmond Cross, first vice-president; Cornelius R. Agnew, treasurer; Fairfield Osborn, secretary; and Messrs J. Watson Webb, DeForest Grant, Warren Kinney, W. Douglas Burden, Ogden L. Mills, C. Suydam Cutting, Childs Frick, Alfred Ely, Herbert L. Satterlee, Laurance Rockefeller, Robert Gordon McKay and Bayard Dominick. There were also present Dr. W. Reid Blair, director of the park; Dr. Charles H. Townsend, director of the aquarium; Messrs. William H. Latham, park engineer, Department of Parks; and George L. Quigley, borough director, Department of Parks. In addition to matters involving the administration of the park and aquarium, the following matters of particular interest were presented at the meeting:

The Permanent Wild Life Protection Fund, created by the late Dr. William T. Hornaday and which was under his direction until his death on May 6 last, was formally accepted by the society under whose management it was placed under the terms of Dr. Hornaday's will. The capital of this fund approximates $130,000 and the use of the income therefrom will naturally result in materially broadening the scope of the society's activities in wild life conservation.

In this connection resolutions were passed at the meeting aimed at the establishment of a bear sanctuary on Admiralty Island on the southeast coast of Alaska; the extension of boundaries of Yosemite Park to insure forest conservation; and the establishment of a national park on the Olympic Peninsula.

It was announced that subscriptions of certain trustees and friends of the society are now adequate to in-

sure the carrying out of the work of Dr. William Beebe and his staff for the remainder of the current year at the station at Nonsuch Island in Bermuda, which has been used for several years previously for marine study.

A report was also submitted regarding the plans which are under way through which the society will be represented at the World's Fair in 1939. To date these plans include a so-called bathyspherium, which is being designed to exhibit deep sea life, together with novel types of aquarium exhibits.

There were also presented at the meeting certain projects which are under consideration for broadening the usefulness of the society to the public, particularly in connection with educational activities and in the development of zoological research work through the medium of a new laboratory in the animal hospital which has just been opened.

Among the more recent exhibits at the park are a Masai giraffe, a pair of secretary birds, an Asiga gazelle antelope from Russia and a wattled crane from East Africa—the two latter being displayed for the first time at the park.

It was reported that the attendance at the park was in excess of one million visitors through May 31, and the attendance at the aquarium was 965,209, being substantial increases over the similar period of the preceding year.

After the meeting the annual garden party was held on the lawns in front of the Administration Building attended by more than six hundred members and friends of the society.

FAIRFIELD OSBORN

THE ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

THE Society for the Promotion of Engineering Education is holding this week its forty-fifth annual meeting at Harvard University and the Massachusetts Institute of Technology.

Conferences, designed to supplement the general sessions, include round-table discussions, presentation of papers dealing with various phases of the engineering curricula and laboratory inspections at both Harvard University and at the Massachusetts Institute of Technology. The subjects planned for discussion include cooperative engineering courses, drawing and descriptive geometry, electrical engineering, engineering economy, English graduate work, guidance of pre-college students, industrial engineering, machine design, mathematics, mining and metallurgy and the professional status and employment of engineering graduates.

At the opening session, Dr. Vannevar Bush, vice-president of the Massachusetts Institute of Technology and dean of engineering, with Dean-elect Harald M. Westergaard, of the Graduate School of Engineering of Harvard University, and Carl S. Ell, chairman of the New England Section of the society, welcomed the gathering. Following a response by President Hammond on behalf of the society, Dr. Karl T. Compton spoke. President Hammond then gave the annual presidential address, for which he chose as his subject "The Engineering Teacher." President Hammond presided at the annual dinner on Thursday evening at which President Henry M. Wriston, of Brown University, was the principal speaker.

Papers on the program read at the meetings include addresses by Henry W. Holmes, dean of the Graduate School of Education of Harvard University, on "Practical Outcomes of the Study of Education Since 1900," and by President William O. Hotchkiss, of the Rensselaer Polytechnic Institute, on "Administering the Faculty"; Frederick M. Feiker, executive secretary of the American Engineering Council, presented a paper on "The Teacher and the Social Significance of the Engineer." Other speakers were Professor Warren K. Lewis, of the department of chemical engineering of the Massachusetts Institute of Technology; Professor Thomas N. Whitehead, of Harvard University; Professor Virgil M. Faires, of the Agricultural and Mechanical College of the University of Texas; Professor Frank L. Eidmann, of Columbia University, and Dr. Paul Cloke, dean of the College of Technology of the University of Maine.

HONORARY DEGREES CONFERRED BY YALE UNIVERSITY

ELEVEN honorary degrees were conferred by Yale University at its commencement on June 23. These included the doctorate of science on Dr. E. O. Lawrence, of the University of California, and on Dr. John H. Northrop, of the Rockefeller Institute for Medical Research. Dr. William Lyon Phelps, public orator of the university, presented the candidates, and President Angell conferred the degrees. The citations were as follows:

Ernest Orlando Lawrence, Sc.D.

Professor Phelps:

Physicist. Born in the twentieth century in South Dakota. A student of St. Olaf College, Northfield, Minn., holding bachelor's and master's and doctor's degrees from the University of South Dakota, University of Minnesota, University of Chicago, and Yale, where he subsequently became national research fellow and assistant professor. Dr. Lawrence is now Professor of Physics at the University of California. His researches in the structure of atoms, atomic nucleus, transmutation of atoms, interaction of radiation and matter, have given

him a world-wide reputation. He is the inventor of the cyclotron that gives to atoms the speed of lightning, enabling them to transmute the chemical elements at a greater rate than was hitherto possible. He is the discoverer of radio-sodium, destined largely to replace the costly radium in many of its uses for the alleviation of human suffering. His reputation would be remarkable for any scholar, but for one in his thirties, it is astonishing. It is also fortunate; for both Dr. Lawrence and the cause of science which he serves may look forward to many years of constantly increasing work and service. This modern alchemist has transformed the elements into one another and has produced forms previously unknown, but with rare self-control has refrained from changing the baser metals into gold.

President Angell:

A brilliant young general in the ranks of physical science, whose dramatic victories are everywhere recognized, your Alma Mater is glad to add to the honors you have already won the degree of Doctor of Science admitting you to all its rights and privileges.

John Howard Northrop, Sc.D.

Professor Phelps:

This man, born in Yonkers and with much of his life spent in New York City and in a laboratory in the Rockefeller Institute at Princeton, is paradoxically an outdoor naturalist and sportsman. He earned three degrees at Columbia, and set out in the world with a broad training in botany, zoology and chemistry. Since 1916 he has been in the Rockefeller Institute; but in the appropriate seasons, any one who gets up at dawn will find him outdoors with rod or gun. During the summer months he is in the North Country making important studies of potato culture and its blight, so that he has made a profitable union of work and play, for scientific research and human welfare. In his early days as a traveling fellow he was associated with the great biologist Jacques Loeb. His specialty has been the application of physical and chemical principles to fundamental biological problems. His work has illuminated many fields and he has made significant contributions to knowledge. His discoveries in pure science have also been of service to health. He solved the riddle of the enzyme; invisible ferments that had hitherto been known only by their action. From his investigations have come principles of wide applicability. He has recently shown that the so-called "Bacteriophage principle" is dependent upon a crystalline protein which is increased as the bacterial host is destroyed. These chemical substances simulate living matter in their behavior, and their discovery provides a basis for a broader concept of life itself. We welcome this scholar to-day into the Yale Brotherhood.

President Angell:

It is to devoted scientists like yourself working quietly and without ostentation to discover the fundamental physical and chemical bases of life that men look for advance in the conquest of disease and in the building of wiser patterns of life. In recognition of your distinguished contributions in this field, Yale University confers upon you the degree of Doctor of Science and admits you to all its rights and privileges.

SCIENTIFIC NOTES AND NEWS

A JOINT meeting of the American Association for the Advancement of Science and associated societies, with the Pacific Division and the Southwestern Division, was held at Denver, Colorado, from June 21 to 26. It was the one hundredth meeting of the association, the twenty-first meeting of the Pacific Division and the seventeenth meeting of the Southwestern Division. An adequate report of the meeting, edited by the permanent secretary, Dr. Forest R. Moulton, will appear in an early issue of SCIENCE.

AT a meeting of the Royal Society held on June 17 the following were elected foreign members: Dr. August Krogh, professor of zoophysiology at the University of Copenhagen; Dr. Otto Meyerhof, director of the Kaiser Wilhelm Institute for Biology at Heidelberg, and Dr. Henry Norris Russell, director of the observatory of Princeton University. The Rt. Hon. the Earl of Athlone was elected a fellow of the society under a special clause in the statutes which provides for the occasional election of "persons who either have rendered conspicuous service to the cause of science or are such that their election would be of signal benefit to the society."

AT the commencement of Harvard University, the degree of doctor of science was conferred on Dr. Walter B. Cannon and on Dr. J. A. Cushman, and the degree of doctor of laws on Dr. J. M. T. Finney. The citations read by President Conant were: Walter Bradford Cannon, doctor of science—George Higginson professor of physiology, Harvard Medical School. "A physiologist whose careful experimentation with living animals is unfolding to generations of future doctors new knowledge of those immutable laws which govern the human body." Joseph Augustine Cushman, doctor of science—of Sharon, Mass., biologist, director of the Cushman Laboratory for Foraminiferal Research, also on the Harvard faculty. "A pioneer biologist whose microscope explores the geologic ages, a guide to men who pierce the earth in search of liquid treasure." John Miller Turpin Finney, doctor of laws—surgeon, of Baltimore, Md. "A surgeon never contented with his skill, a wise statesman among those who yearly work fresh miracles with the knife."

THOSE on whom honorary degrees were conferred by the University of Wisconsin at its commencement on

June 21 included the doctorate of laws on Dr. William O. Hotchkiss, geologist and president of the Rensselaer Polytechnic Institute, and on Dr. David Riesman, professor of the history of medicine at the University of Pennsylvania. The doctorate of science was conferred on Dr. Harry A. Curtis, chief chemical engineer of the Tennessee Valley Authority.

DR. JOSEPH ERLANGER, professor of physiology at Washington University, St. Louis, was awarded the honorary degree of doctor of science at the one hundredth annual commencement exercises of the University of Michigan.

AT its one hundred and sixteenth commencement Colby College conferred the honorary degree of doctor of science upon Dr. Leslie B. Arey, Robert Laughlin Rea professor of anatomy at Northwestern University.

DR. WILLIAM KENDRICK HATT, of Purdue University, was given the honorary degree of doctor of science by the University of New Brunswick on May 14, in recognition of his researches in the field of civil engineering.

HENRY FIELD, curator of physical anthropology at the Field Museum of Natural History, has sailed for England to receive a degree of doctor of science from the University of Oxford, in recognition of the research that he has conducted at the museum, the work he has performed on several expeditions for the institution and the many comprehensive scientific reports that he has written.

THE American Association for the Advancement of Science at its Denver meeting made the first award of the Theobald Smith Prize of $1,000, established by the Eli Lilly Company of Indianapolis. The award was made to Dr. Robley D. Evans, assistant professor of physics at the Massachusetts Institute of Technology, for his method of detecting radium poisoning.

OFFICERS of the American Society of Plant Physiologists for the year 1937–38 have been elected as follows: *President,* Dr. O. F. Curtis, Cornell University; *Vice-president,* Dr. W. F. Loehwing, the State University of Iowa; *Secretary-treasurer,* Dr. F. P. Cullinan, U. S. Department of Agriculture, Beltsville, Md.; *executive committee,* for a three-year term, Dr. R. B. Harvey, of the University of Minnesota; *editorial board,* for a three-year term, Dr. H. R. Kraybill, of Purdue University.

THE following officers of the Harvard Chapter of the Sigma Xi have been elected: *President,* Professor Grinnell Jones, chemistry; *Vice-president,* Professor G. M. Fair, engineering; *Secretary,* Professor F. M. Carpenter, biology; *Treasurer,* Professor B. J. Bok, astronomy. Professor L. C. Graton, of Harvard University, gave on May 18 the annual address on "Controversies Regarding the Origin of Ores."

DR. H. E. BIGELOW, director of the department of chemistry at Mount Allison University in Sackville, N. B., was elected president of the Canadian Institute of Chemistry on June 18 at the annual meeting, which was held at Vancouver. Dr. Bigelow succeeded F. E. Lathe, of the National Research Council at Ottawa.

DR. JAMES ROWLAND ANGELL, retiring president of Yale University, has accepted a full-time position as educational counselor of the National Broadcasting Company.

THE Board of Trustees of Cornell University has conferred on Dr. Livingston Farrand, the retiring president of the university, formerly professor of anthropology at Columbia University, the title of president-emeritus.

RETIREMENTS at the close of the academic year of members of the faculty of the University of Wisconsin include: Dr. Edward Alsworth Ross, professor of sociology; Dean Frederick E. Turneaure, of the College of Engineering; Dr. William S. Marshall, professor of entomology, and Dr. George Van Ingen Brown, of the School of Medicine. These retirements are in accordance with a recent regulation enforcing the retirement of members of the faculty at the age of seventy years.

THE *British Medical Journal* states that Professors Bezançon, Carnot, Claude and Gosset are among the eight French leaders of the medical profession who have been nominated "Professeurs de Classe Exceptionnelle"—a distinction which qualifies them for remaining in office until the age of seventy years.

DR. MAGNUS I. GREGERSEN, professor of physiology of the University of Maryland, has been appointed head of the department of physiology at the School of Medicine of Columbia University. Dr. Walter S. Root, also of the University of Maryland, has been named associate professor of physiology. Dr. Gregersen succeeds Dr. Horatio B. Williams, who resigned as executive director of the department two years ago. Dr. Williams will continue to carry on research and teaching.

DR. FRANK H. LATHROP has been appointed head of the department of entomology at the Maine Agricultural Experiment Station. He succeeds Dr. Edith M. Patch, who retired on June 30 after serving as entomologist of the station since 1904.

DR. RICHARD BRADFIELD, professor of soils at the Ohio State University and associate agronomist of the Experiment Station, has been elected head of the de-

partment of agronomy of Cornell University and professor of soil technology and soil technologist in the Experiment Station. He will succeed Dr. Thomas L. Lyon, who retired at the close of the academic year.

AT Purdue University, Karl D. Wood has been named professor of aeronautical engineering to succeed Professor G. W. Haskins, who has resigned to reenter the aviation industry after being a member of the faculty for eight years. Eugene S. Ault, of the Case School of Applied Science, will succeed the late Professor George M. Bartlett as professor of machine design.

DR. C. L. TURNER, professor of zoology since 1930, has been appointed chairman of the department at Northwestern University. Other recent appointments and promotions are: Dr. Orlando Park, promoted to an associate professorship; Dr. Frank A. Brown, Jr., appointed to an assistant professorship; Dr. C. D. Turner, appointed instructor.

DR. J. HOWARD MCMILLEN, research associate in spectrography and electron optics in the department of anatomy of the Washington University School of Medicine, has resigned to become associate professor of physics, Kansas State Agricultural College, Manhattan.

THE Board of Scientific Directors of the Rockefeller Institute for Medical Research announces the following appointments and promotions on the scientific staff to take effect on or after July 1. Promotions: Associate Member to Member, Dr. Max Bergmann; Associate to Associate Member, Dr. Wendell M. Stanley; Assistant to Associate, Dr. Lyman C. Craig, Dr. Lee E. Farr, Dr. Roger M. Herriott, Dr. Alma E. Hiller, Dr. Albert B. Sabin, Dr. Erich Traub. New appointments: Assistants, Dr. Otto K. Behrens, Dr. Lindsay M. Black, Dr. Jaques Bourdillon, Dr. Thomas M. Brown, Dr. Jordi Folch-Pi, Dr. Frank H. Robinson, Jr., Dr. Gerhard Schmidt, Dr. Henry A. Schroeder, Dr. Edwin J. Wellhausen. Resident physician at the Hospital, Dr. Colin M. MacLeod. Fellows, Max A. Lauffer, Jr., Dr. John M. Pearce, Dr. Richard E. Reeves, A. Frank Ross.

DR. B. L. MILLER, head of the department of geology of Lehigh University, has been granted leave for the first semester of 1937–1938. During his absence, Dr. D. M. Fraser will be acting head of the department. Dr. Bradford Willard, of the Pennsylvania Topographic and Geologic Survey, has been granted part-time leave and has been appointed assistant professor of geology during Dr. Miller's absence. Dr. Miller and Dr. Willard are to attend the International Geological Congress in Moscow during the summer.

DR. ALBERT W. C. T. HERRE, curator of ichthyology in the Natural History Museum, Stanford University, has returned from ten months spent in collecting in the Orient. Collections of fishes were made in the Chusan Islands and Chekiang and Kwangtung Provinces, China, in the Philippines, in British North Borneo and Sarawak, Borneo, in Malaya, in Burma and in India.

DR. E. L. DODD, professor of pure mathematics at the University of Texas, has been given leave of absence from September 15 to November 1 to enable him to attend the Congress on the Theory of Probability at Geneva.

ON May 17, Dr. W. H. Stoner, of the Burroughs Wellcome and Company Experimental Research Laboratories, lectured to the staff and students of the School of Medicine of Duke University on "Sulfamilamide Therapy," and on May 31, Dr. Jonas S. Fridenwald, of the Wilmer Ophthalmological Institute, the Johns Hopkins Hospital, lectured on "Interpretation of Retinal Changes."

DR. DETLEV W. BRONK, director of the Johnson Foundation for Research in Medical Physics and director of the Institute of Neurology at the University of Pennsylvania, delivered on June 6 the annual address of the Swarthmore chapter of Phi Beta Kappa on "The Social Significance of Intellectual Leadership."

ACCORDING to the will of the late Charles Lathrop Pack, $50,000 has been left in trust for the Charles Lathrop Pack Forestry Trust; $2,000 to the Society of American Foresters, and $5,000 each to the Institute of International Education and the state of New Jersey for the acquisition and maintenance of forest tree nurseries or planting. During his lifetime Mr. Pack had given large sums for the support of forestry and conservation.

LUCIUS N. LITTAUER, of New York City, has given a seven-story building on the southwest corner of Irving Place and Eighteenth Street to the National Hospital for Speech Disorders. The institution will in future be known as the Lucius N. Littauer Institute for Speech Disorders. The building, formerly occupied by the New York Telephone Company, will be remodeled and equipped by Mr. Littauer and will represent a gift estimated at from $200,000 to $225,000. The amount of the endowment has not been made public.

THE daily papers report that Henry Dazian, of New York, a leading theatrical costumer, has left the greater part of his estate to establish the Dazian Foundation for Medical Research. The object of the foundation is the advancement of medical or allied scientific knowledge and the establishment of fellowships. A self-perpetuating board of five doctors of

medicine and four laymen was designated by Mr. Dazian to conduct the foundation. They are: Dr. Alexis Carrel, of the Rockefeller Institute; Dr. Emanuel Libman, professor of clinical medicine at Columbia University; Dr. Israel Strauss, neurologist, and Dr. Philip Finkle, all of Mt. Sinai Hospital; Dr. Harrison S. Martland, of Newark, N. J., pathologist and medical examiner of Essex County, New Jersey; William W. Cohen, a nephew, and the three executors of the estate, Alfred L. Rose, Harold Williams and Emil Friedlander, of Great Neck, L. I. Twenty-five years after his death, the principal of the foundation's trust fund is to be distributed to hospitals, sanatoria and similar institutions selected by the board.

A GIFT of $6,000 has been made to St. Louis University for the promotion of research in seismology and geophysics. It will be used over a three-year period, under the direction of the Rev. James B. Macelwane, S.J. Two fellowships in geophysics will be made available.

ACCORDING to the *Journal* of the American Medical Association, it is planned to open a branch of the Milan Serotherapy Institute at Addis Ababa in the near future. The construction of the building was recently begun.

THE Medical College of Virginia, Richmond, has under construction its first dormitory for men at a cost of $315,000. This building will house the house staff of the college hospitals, approximately fifty, and the senior medical class, its total capacity being one hundred and forty-seven. The building will be located in the hospital center and will contain in addition to the typical dormitory rooms a cafeteria, private dining rooms, an assembly room seating one hundred and fifty, barber shop and other facilities. The building will be dedicated next spring, probably during the centennial celebration of the college.

DISCUSSION

RECOGNITION OF MINERALOGISTS

As of December, 1936, the Mineralogical Society of America had 154 fellows and 387 members according to the report of the secretary. This society is the only one of high professional standing in America which includes crystallographers, mineralogists, mineralographers, petrographers and petrologists (as contrasted to geologists in general), and which is continent-wide. The membership also includes ceramic and cement scientists, as well as representatives of all those numerous industries whose research staffs make use of chemical microscopy, as so ably outlined by the address of the retiring president.[1] The following remarks are based on the most recent membership list[2] and on "American Men of Science" (5th ed., 1933—hereafter referred to as A. M. S.).

Two hundred and two of the fellows and members are listed in A. M. S.; this includes 117 fellows, all of those resident in North America except 17. Of these 202, 26 fellows and 1 member have a star in A. M. S., in which work stars are assigned only to residents of the United States. The 27 with stars received these at ages 25 to 62, average 43 1/3, and in 1937 their ages ranged from 50 to 80, average 62+.

Of these 27

9 are economic geologists (all but one metalliferous)
6 combine mineralogy and petrology
4 combine one or both of these with other fields
5 are petrologists (or petrographers)

2 include a geophysicist and a botanist
1 is a crystallographer-mineralogist

Of these 27, 15 received their stars while with some governmental bureau or the Carnegie Institution (at Washington in all but one case), and therefore were doing no teaching; this includes 2 who received their stars one or four years after leaving the U. S. Geological Survey to accept teaching positions.

If only those 16 of the 27 primarily in mineralogy and petrography are considered (eliminating the nine economic geologists, many of which profession are not members of the M. S. A., and the two miscellaneous), it is found that one half or 8 received their stars while in non-teaching work (or in two of these cases shortly after starting to teach). These 8 non-teachers received their stars at ages 33 to 55, average 44 –, and in 1937 are aged 50 to 74, average 58½. The other 8, the professional-teacher mineralogist-petrologists, received their stars at ages 36 to 50, average 44½, and in 1937 are aged 60 to 80, average 69. Further data regarding these 16 are given in Table 1.

Only two teachers have received stars since 1910.

TABLE I

Date of star	Teachers		Non-teachers		Both	
	Number of stars	Average age*	Number of stars	Average age*	Number of stars	Average age*
1933 ...	0	–	2	54	2	54
1927 ...	1	50	2	44	3	46
1921 ...	1	47	2	39	3	42
1910 ...	4	42	1	33	5	40
1906 ...	2	46	1	43	3	45

* Of receiving stars.

[1] W. S. Bayley, *Amer. Mineral.*, March, 1937, 147–168.
[2] *Ibid.*, 227–239.

Except for the first edition it is very clear that for both groups the average age of receiving a star is increasing at an alarming rate, much faster than the physicians are raising the life span and on the average the non-teachers receive a star at an age nearly eight years under that for teachers. While these statistics are not suitable for drawing any very definite conclusions, it is worth pointing out that: (1) While the number engaged in mineralogy-petrology is constantly and very rapidly increasing[3] the total number receiving stars is more or less static: (2) that during the specialization which has been most pronounced in the geological sciences since the war it may have been impossible for geologists in general (outside of the relatively coherent Washington group) to vote intelligently on all the individuals in all the different sciences involved; (3) although the average age at which geologists received a star (49.4 in the last edition) is higher than that in any other science recognized by the editor, it is nearly 5 years under that applying to the mineralogist-petrologists; and (4) crystallography-mineralogy is such a highly specialized field that it is well-nigh impossible to receive recognition by outsiders for work done in it.[4]

D. JEROME FISHER

UNIVERSITY OF CHICAGO

MORE BRAINS AND LESS MONEY

How many people to-day, even those pursuing the higher curricula of learning, students of science in general and those studying psychology in particular, understand the mechanics of the very laboratory apparatus they use daily?

That the layman regards the science laboratory as a place where wonders and miracles are wrought is a known fact. Those who have observed groups of people viewing a laboratory know with what awe and reverence the apparatus is looked upon. This is like hero-worship, like the superstitious regard primitive people hold for the natural events of the universe.

I recall, in this instance, my own experience in the eighth grade, where physics of a kind was taught under the heading of "general science." The event that stands out clearly in my mind is a demonstration of electricity with the Wimshurst machine. Truly, I had never been so impressed, so mystified and awed at the spectacle. To the entire class the demonstration was an exhibition in magic. Our curiosity was challenged; nevertheless, we could not fathom how the contraption produced electricity. Our notes told us something of brushes rubbing each other, thus producing sparks, but we felt the explanation inadequate if not incomprehensible.

As a student I had similar experiences with my classmates and found the same true of my own students in the psychology laboratory. It seems to me that students, in general, have two major intellectual fears—the fear of mathematics and of laboratory apparatus. Both of these items are little understood and mastered only by a few. The rest of the students carry away with them a feeling of inadequacy or inferiority, even dislike for these tasks, because they do not—not that they can not—master them.

The pursuit of science to-day, even in an elementary course, is a very complicated task. Our derived data must come out through a highly technical complex process which is far removed from the meaning of the actual results obtained. For example, many people know how to "snap" pictures, but this does not mean they can explain the process of photography from its physics and chemistry point of view, which is the true explanation. Similarly, students learn operations and manipulations of complex apparatus but do not know the significance of their work. Therefore, the benefit derived from a laboratory course is very much reduced. The educational world seems to be interested in data and not in how the data are secured. This is a decided handicap to clear and effective thinking, as I see the problem. I am inclined to the view that by this means of a synthetic laboratory training we tend to inculcate into the student mind a superficiality as regards the critical examination of phenomena. Decidedly, we steer the student away from the *cause* of events and insist, indirectly, that the *effect* is all that matters—the data are what the student has to examine and not the means of securing the data.

Circumstances have arisen which forced upon us the opportunity to redirect the emphasis on laboratory study. With little or no apparatus available we were asked to teach psychology as a laboratory science. True, we could have borrowed apparatus, but such was not our purpose. The simple and obvious plan was to make apparatus-construction a part of the laboratory procedure. Consequently, I asked for volunteers to construct mazes, mirror-drawing apparatus, tachistoscopes, apparatus for conditioning sight and sound to electric shock, coordination boards, which registered the number of contacts by means of a door-bell buzzer, weights to be used for the size-weight illusion experiment and many other pieces of apparatus needed in a laboratory of general psychology, as a color-wheel, etc.

While I acted as adviser, the students really built the apparatus with their own ingenuity. I would refer them to text-book plates and laboratory manuals; at the same time I was cautious not to do the thinking

[3] Well shown by the graph on page 201 of the March, 1937, number of *The American Mineralogist*.

[4] F. B. Littell (SCIENCE, May 14, 1937, 477) finds that international "Who's Who" for 1937 lists 6 British mineralogists (among 336 scientists) but only 3 from the U. S. (of 605 scientists).

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for the students. When the apparatus was handed in the student would also submit a diagram and a report on how he mastered the problem and what difficulties he encountered in the construction. The application of the apparatus was left for laboratory experimentation.

Comments like these were to be found in the student reports: "I really enjoyed making the apparatus, since it provided enjoyment and a realization that the finished product was of my creation and was to be used for the benefit of the present and future psychology classes."

Again, the student would report difficulty in construction and how he solved the problem: "The difficulty I encountered was the method of raising and lowering the drop (of the tachistoscope), which I finally solved by using the strings as I explained."

By this means the students gained insight into the purpose of laboratory apparatus. As well, the effect on the mind of the student and upon the learning activity as a whole was a highly desirable one. The students felt an intimate acquaintance if not kinship in using apparatus which they constructed and knew how to use.

Even if I had all the laboratory apparatus at my disposal I would still favor a plan whereby the apparatus should be disassembled in order to allow the students to reassemble the parts for each experiment.

ADOLPH M. KOCH

YONKERS COLLEGE, N. Y.

MICROPHOTOGRAPHS AND PHOTOMICROGRAPHS

IN regard to the controversy over the correct usage of "microphotograph" and "photomicrograph," I have found the following notation in the Oxford Dictionary (1928), under Photomicrograph: "In 1858 G. Shadbolt in 'Sutton's photographic notes' says: 'The word microphotograph originated, I believe, with myself and is applied, I think correctly, to very small photographs, not to photographs of very small objects which would more correctly be photomicrographs.'" However, by 1860 microphotograph was used incorrectly (according to the Oxford Dictionary) and since then seems to have been used rather loosely by all.

Since it would seem that the originator of a word should have the authority to interpret its meaning, it follows that microphotograph should indicate a microscopic photograph, and photomicrograph a photograph of a microscopic object.

W. L. SHILLING

ST. JOSEPH, MO.

SCRIPTA MATHEMATICA

THE article "Dinner of the Society of Friends of *Scripta Mathematica*" (SCIENCE, No. 2212, p. 492) contains several inaccuracies due to errors inadvertently committed in the office of Scripta.

(1) The dinner was held in honor of Professors Eric Temple Bell, Cassius Jackson Keyser, David Eugene Smith and Mr. M. Lincoln Schuster for their contributions to public enlightenment regarding mathematics as an essential means to general culture. The opening address was made by Professor William P. Montague.

(2) *Scripta Mathematica* is a quarterly journal devoted to history and philosophy of mathematics published by Yeshiva College, and is edited by Jekuthiel Ginsburg with the cooperation of Raymond Clare Archibald, Adolph Frankel, Sir Thomas Little Heath, Louis Charles Karpinski, Cassius Jackson Keyser, Gino Loria, Vera Sanford, Joseph J. Schwartz, Lao Genevra Simons and David Eugene Smith.

(3) Among the Scripta publications in preparation are a volume entitled "Fabre and Mathematics," by Professor Lao G. Simons, and a volume entitled "Forum Lectures," being addresses given before the Forum of *Scripta Mathematica* by Professors Cassius Jackson Keyser, David Eugene Smith, Edward Kasner and Walter Rautenstrauch.

JEKUTHIEL GINSBURG

SCIENTIFIC BOOKS

REMINISCENCES OF J. J. THOMSON

Recollections and Reflections. By SIR J. J. THOMSON. New York: The Macmillan Company. Pp. v + 451. $4.00. 1937.

OF the many delightful characteristics of this most fascinating book, not the least is inherent in the simplicity and informal type of presentation. In many cases the author writes as though he were speaking to us, and we are brought into a very close personal touch with those situations which have marked the milestones in his life. When he informs us that "the examination for the Mathematical Tripos was an arduous, anxious, and very uncomfortable experience," and that it was "held in a room in which there were no heating appliances of any kind," and as we follow him through the description of the examination, we find ourselves transported in mind through more than half a century, and feel a real sympathy with that young man about to take the examination which means so much in his life. We are worried when we read that he suffers an attack of insomnia five days before the examination. We sincerely hope he will recover. On the morning of the examination we are quite nervous, but are relieved

when we know that the feeling of fatigue has passed away. We feel that it was a wise idea to take a shampoo between the morning and the afternoon examinations. We are a little disappointed that our hero comes out second, instead of first; but our disappointment is mellowed by the thought of the great richness which is to follow.

The fact of personal companionship with the writer remains with us throughout. The book abounds with incidents having to do with the various people with whom the author has had associations; and, while all is kindly said, Sir Joseph does not hesitate to voice his criticism when the occasion arises. We read how the mathematician, J. W. L. Glaisher, on being introduced to a pretty girl, would straightway go home and write a sonnet about her. We read that "he once stabbed a man and there was the dickens of a row. This gave a certain liveliness to his lecture, etc." We go on to read that "the dullness (as lecturers) of some of his contemporaries was hardly to be imagined."

Particularly interesting are the detailed accounts of methods of thought and work of some of the notable teachers and scholars of Cambridge whose activities have only been known to many of us through the formal channels of their writings. Among the more interesting of these is the short biography of E. J. Routh, the most celebrated mathematical coach of all time in Cambridge, a man who was the grandfather of more successful candidates in examinations than almost any other man living. The details of Routh's methods in instruction are most illuminating and can not help but be of profound interest to teachers in all generations, whether they would agree with or oppose the methods employed.

Among the most interesting parts of the book are those in which the author expresses his views concerning matters pertaining to education in general and to its relation to research. Those who, in our teaching institutions, consider themselves overburdened with teaching, will read with interest: "I am strongly of opinion that in general some teaching should be combined with research, and that the teacher should not regard his teaching as negligible in importance compared with his research. There is no better way of getting a good grasp of your subject, or one more likely to start more ideas for research than teaching it or lecturing about it, especially if your hearers know very little about it, and it is all to the good if they are rather stupid." Then again, "It is, I think, a general experience that new ideas about a subject generally come when one is not thinking about it at the time, though one must have thought about it a good deal before."

It presents the great J. J. Thomson in a new light when we read of his efforts to coach a pupil for the Tripos. He voices his satisfaction in declaring that the success of this man "was the greatest teaching triumph I ever had, for he was quite unable to follow any kind of mathematical reasoning. He could, however, learn pieces of book work off by heart, but without understanding them. I made him write out over and over again every piece of book work that was at all likely to be set in the elementary part of the Tripos until he could do them without mistake. This, however, did not make him safe, for there was no certainty that he could write out the right piece of book work in answer to a particular question, if the wording of the question differed to an appreciable extent from that to which he was accustomed. The issue became almost one of probability: if you have a number of balls, each with different numbers, and throw them at random into an equal number of holes, each hole having a number corresponding to that on one of the balls, what is the chance that the number of balls which go into the right holes is not less than the number of questions you have to answer correctly to get through the examination? Fortunately he had good luck and so obtained an Honours degree in mathematics in Cambridge University."

Speaking of the system of scholarships for undergraduates so prevalent in English universities as compared with the principle of working one's way through college, Sir Joseph, referring to the prevalence of the latter method in this country, remarks, "A considerable number did this by acting as waiters in summer hotels, tram conductors. . . . This all takes time and work and those who had to do it were seriously hampered in their studies. To reduce the necessity for this extra work it is very important to keep university expenses down as much as possible."

A suggestion arising out of the appointment of a professor in an American university will interest many in the scholastic field. Sir Joseph, on being consulted regarding the appointment to a certain chair of physics through the intermediary of the American ambassador, comes to the point where the matter of salary is being discussed. It seems that the salary available is rather low. However, the ambassador points out that though the salary was low, many wealthy men lived near to the university. These men had daughters, and professors held a very good social position in America, so that the successful candidate would have no difficulty in securing a wealthy wife.

Passing through the author's boyhood and early college and undergraduate days in Cambridge, in which we make the closer acquaintanceship of many lights of science formerly known to us only through their writings, we come to the history of the activities of the Cavendish Laboratory. Here again, we meet in personal intimacy such names as Clerk Maxwell, Lord Rayleigh, Sir Richard Glazebrook, Lord Rutherford,

H. R. Wilson, and indeed the whole galaxy of those names which have been associated with the growth of that great institution. We see the author actually working in the laboratory, not only in his researches, but in organizing courses for the teaching of the youth. We see him concerned with the matters of finance of the laboratory and we find him confronted with the problem of how to make both ends meet. We find a bond of sympathy with him when, speaking of a method of accumulating finances for the laboratory from certain fees he takes us into his confidence and remarks: "Another advantage is that it is possible with this system to wait until an instrument is wanted before buying it. In the more usual practice, when the University takes the fees and makes a grant to the Laboratory for apparatus, unless you spend the money in the year for which the grant is made, the authorities responsible will think that the grant is greater than you need and reduce it."

A chapter is devoted to psychical research, to such things as telepathy, water-dowsing and the like. It is interesting here to find that Sir Joseph has participated in many investigations in these fields. His attitude is always broad-minded. He usually leans to the side of seeking some ordinary physical explanation of the phenomena demonstrated, but is in no sense dogmatic and leaves his mind open to the possibility of the existence of phenomena in these realms to an extent which may be surprising to some who view these matters with but little sympathy. In this field, of course, we encounter other famous names of men who have been interested in the occult, Lord Rayleigh, Sir Oliver Lodge, and many others.

American readers will find much of interest in the history of Sir J. J. Thomson's visits to this country. His description of witnessing a game of baseball is particularly amusing. He tells us how the game had only been going on for a few minutes when most of the lawyers, doctors, bankers, professors and clergymen witnessing it had lost their power of articulation through cheers and exaltation, so that they could only croak. He adds, "I always myself get very much excited by a keen contest and feel for the moment that nothing on earth matters so much as that the side I am interested in should win." However, American enthusiasts will be much amused by his endeavoring to explain the game of baseball to Englishmen by comparing it with an English game of rounders, which is usually played by children with a soft ball, and in which the pitcher is replaced by one whose business is to throw the ball sufficiently straight so that you can hit it; and if you can't hit it, you get another pitcher. We are interested to observe Sir Joseph's opinion to the effect that if Woodrow Wilson had been a better diplomat conditions would not have developed so that he left Princeton. He would consequently not have become President of the United States during the great war.

There are interesting descriptions of the various colleges and educational centers in America. There is a certain tendency to inaccuracy in detail in some of these citations. Thus, we read of the University of Philadelphia. We read of Bryn Mawr University. The Institute for Advanced Study at Princeton is cited as an adjunct to Princeton University. We also read of the Universities of Haverford and Swarthmore.

Sir Joseph evidently came under the spell of the many amusing stories which are told of Bryn Mawr and concerning the period of presidency of Miss Carey Thomas, who, we read, "was a very capable woman with a very pronounced personality. She used the mailed fist rather than the gloved hand, and domineered over the staff and the governors." We have a citation of many of the amusing stories which are told in relation to that very prominent personality who ruled Bryn Mawr for so many years. Then follows a description of a visit to Canada and to Berlin. A chapter is devoted to Sir Joseph's association with work carried out during the war. In connection with his second visit to America to lecture at the Franklin Institute, a goodly account is given of the work of Benjamin Franklin. Next follows a chapter dealing more specifically with the history of Trinity College, Cambridge, and of Trinity College men with whom Sir Joseph has come in contact during his life. Finally, there is a chapter summarizing many of those researches with which the author has been more particularly associated, and which have played so great a part in building up the reputation which the Cavendish Laboratory possesses as one of the great research laboratories of the world.

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AUSTRALIAN PRE-CAMBRIAN FOSSILS

Australian Pre-Cambrian Fossils: A Memoir of the Late Pre-Cambrian Remains from the Adelaide Series, South Australia. By SIR T. W. EDGEWORTH DAVID and R. J. TILLYARD. Angus and Robertson, Sydney, Australia, 1936, 122 pages and 13 plates, 7s-6.

How, when and where life first began have long been baffling questions. For years the exact answers have eluded scientists, although periodically zoologists or paleontologists have been able to throw a little light on the subject. Now at last the biologists almost daily have new information concerning the borderland between the living and the lifeless. But whatever their findings, it will always be the record of the past that is most likely to yield definite replies to queries concern-

ing the origin and relationships of many of the *higher* animal and plant lines. For instance, the high stage of evolutionary advancement shown by Cambrian trilobites, chief members of the earliest well-recorded faunas, gives clear indication of the millions of years involved in the organic development of the invertebrates prior to the beginning of the Cambrian period. Consequently, it is not surprising that geologists and paleontologists for well over a half century have expended a great deal of their energy in the attempt to find identifiable *pre*-Cambrian fossils.

Among the most energetic and enthusiastic of the searchers for the primitive ancestors of the early Paleozoic invertebrates has been the late Sir Edgeworth David. With keen insight, unwearying patience and unflagging determination Professor David continued his quest in the pre-Cambrian sediments of South Australia over a long period of years. Finally he triumphed in the discovery of what he was convinced were beyond doubt the definite remains of pre-Cambrian invertebrate animals. One of Professor David's early publications in connection with this problem concerned the remains of small crustacea in the rocks of Reynella, near Adelaide, but in 1922, when this paper was issued, he was not sure that the rocks in question were pre-Cambrian in age. In 1928, however, he published another paper on newly discovered fossils in the Adelaide series which at that time he doubtfully referred to the so-called Lipalian interval. This latter paper attracted a great deal of attention, particularly because in it was figured a pre-Cambrian eurypterid.

The present memoir stems from this earlier work and is partly the result of a grant made by the Royal Society. The money was expended in opening two quarries, one at a spot called Tea Tree Gully, eleven miles northeast of Adelaide, the other at Beaumont, a suburb of Adelaide. The material described and figured by David in 1928 was so fragmental that even in Australia, where the specimens were available for inspection, scepticism as to their being authentic was wide-spread. As a result of the more complete nature of the more recently quarried material, it is stated that practically all Australian scientists are now agreed that the specimens uncovered are genuinely organic.

The fauna of the Adelaide series is regarded as belonging to three horizons, in order from the oldest to the youngest—(a) the Tea Tree Gully, (b) the Beaumont and (c) Brighton. The Sturtian glacial beds intervene between the Brighton and the Beaumont formations. The Tea Tree Gully fauna contains giant annelids and arthropods, the largest of the latter having an estimated length of approximately ten feet! The Beaumont fauna contains giant annelids and arthropods, a possible ancestor of the cephalopods, a large phyllocarid, problematical minute brachiopods and a probable pteropod. The annelids and arthropods of this fauna show a considerable evolutionary advance over those from the Tea Tree Gully quartzite, which is stratigraphically about 3,500 feet below the Beaumont beds.

The Brighton assemblage is characterized by a marvelously preserved, apparently dwarfed fauna of annelids and arthropods, partly post-glacial, partly glacial in age. The writers suggest that the severity of the Sturtian ice age accelerated, if it did not indeed cause the almost complete extinction of the giant annelids and arthropods of the Tea Tree Gully and Beaumont horizons, and that the Sturtian refrigeration was a catastrophe to the contemporaneous marine life similar to the one during the late Paleozoic glaciation.

There is a question as to whether the Adelaide series should be considered (1) an infra-Cambrian part of the Paleozoic, (2) a Lipalian sequence filling the gap between the generally recognized base of the Cambrian and the top of the Proterozoic or (3) a definite Proterozoic series. The writers, however, stress the following points: (a) The Tea Tree Gully beds are stratigraphically 17,000 to 23,000 feet, and the Beaumont 14,000 to 20,000 feet, below the definitely lower Cambrian Protolenoid horizon in the Archeocyathid limestone series. (b) At least one erosional interval is recorded in the Adelaide series. (c) The Sturtian tillite probably is to be correlated with the Keweenawan [sic] tillite of North America, the Numees tillite of South Africa and the Yangtse tillite of South China. (d) The fossils themselves are all vastly different from any previously described organisms. In fact, they differ more from the Cambrian types than do the Cambrian fossils differ from the Carboniferous. Accordingly, Professor David, before his death in 1934, expressed the opinion that the Tea Tree Gully and Beaumont faunas lived during the later Proterozoic, but he thought the Brighton fauna might possibly be as young as Lipalian.

In the present memoir only five fragmentary specimens from the Tea Tree Gully horizon are dealt with. These are described as two closely related species belonging to the new genus *Protadelaidea,* of which the genotype is *P. howchini.* Professor Tillyard considered these species the sole known representatives of a new class, Arthrocephala, of the phylum Arthropoda. This new class is characterized by the four unfused segments which form the prosoma, or head region, and by the primitive structure of the abdomen, which does not carry segmented appendages. Professor Tillyard has had the temerity to include relatively detailed restorations of *Protadelaidea,* showing both the dorsal and ventral surfaces. He has carefully compared *Protadelaidea* with a number of other Ar-

thropoda, such as the Onychophora, the Crustacea and the Trilobita. The conclusion is reached, however, that it was arachnoidian in type and had a common ancestor with the eurypterids, though it was not the direct ancestor of the latter group. A significant relationship is also noted between the Arthrocephala and the Crustacea (especially the metanauplius larva), indicating a common ancestry for these two large groups earlier in the Proterozoic.

Some idea of the difficulty of the task which originally confronted Professors David and Tillyard may be gleaned from the fact that to procure the few specimens of arthropods dealt with in this memoir, about fifty-five tons of hard quartzite were quarried, and about seven tons of carefully selected blocks were meticulously split into thin slabs. The present publication was to have been merely the first of a long series describing the other pre-Cambrian finds, but even as this review is written word comes of the death by automobile accident of Professor Tillyard, on January 13, 1937. It is to be hoped, however, that some one can be found who will be able to carry on these extraordinary researches of David and Tillyard in the same high plane in which they have so long prosecuted the work.

Notwithstanding the great reputation of the authors and the evident care which they have given to their work, critics are apt to wonder how it was possible to make the restorations on the basis of the type of specimens illustrated in Plates I to VI; and this wonder may persist despite the fact that many (though rumor has it, not all) of the Australian scientists who have examined this material are inclined to say that "seeing is believing." Furthermore, few students of the North American pre-Cambrian are likely to agree with the writers when they say, with the most naive of provincialism: "Only in a country like Australia, one of the most rigid shields of the earth, where even lower Cambrian strata retain in places their original horizontality, and the rocks are only slightly compacted, and where fossils like trilobites are exquisitely preserved, can one expect to find even the Proterozoic rocks so little altered as to preserve traces of former fossils."

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SOCIETIES AND MEETINGS

THE OHIO ACADEMY OF SCIENCE

THE Ohio Academy of Science held its forty-eighth annual meeting at Columbus from May 13 to 15, 1937, under the joint auspices of the Ohio State and Capital Universities. The attendance was large (about 300), the programs, both general and sectional, well attended and as a rule enthusiastically received, and the atmosphere helpful and inspirational.

The meetings of the academy on Friday morning, May 14, were held in the auditorium of Mees Hall, Capital University, and were devoted, first, to the transaction of business and second, to a general scientific session. The chief items of business were the election of 38 new members and 13 fellows, adoption of a plan to observe in a fitting manner the semi-centennial of the organization of the academy two years hence, the selection of the College of Wooster, Wooster, Ohio, as the place for holding the 1938 meeting, the election of the present vice-presidents as a nominating committee for the 1938 meeting, the approval of the annual reports of the officers and various committees, and the election of the following officers for the ensuing year, *viz.: President,* Charles G. Shatzer, Wittenberg College; *Vice-Presidents*—A. Zoology, Warren Spencer; B. Botany, Raymond A. Dobbins; C. Geology, John L. Rich; D. Medical Sciences, Bruce K. Wiseman; E. Psychology, Harold E. Burtt; F. Physics and Astronomy, Dayton C. Miller; G. Chemistry, W. C. Fernelius; *Secretary,* William H. Alexander; *Treasurer;* Eugene Van Cleef; to the *Executive Committee,* Dr. Charles A. Doan and A. W. Lindsey.

The general scientific session was unusually rich, consisting of three outstanding features: First, an illustrated address on "Scientific Research in the Antarctic," by Dr. F. A. Wade, of Miami University, Oxford, Ohio; second, two reels of moving pictures showing "High Speed Moving Pictures of Selected Biological and Physical Phenomena," made by Professor Edgerton, of the Massachusetts Institute of Technology, secured and presented by Dr. Alpheus W. Smith, of Ohio State University; and third, an illustrated address on "Certificates of Growing Up and Growing Old," by Dr. T. Wingate Todd, of Western Reserve University.

Every one agrees that the annual dinner was another notable achievement. Dr. Laurence H. Snyder, chairman of the local committee on arrangements, presided most delightfully, introducing the various speakers and guests in a very happy manner. President George W. Rightmire, of Ohio State University, and President Otto Mees, of Capital University, welcomed the academy most graciously, and President Doan responded briefly. The toastmaster then introduced Dr. Otis W. Caldwell, of the Boyce Thompson Institute for Plant Research, the genial and popular general secretary of the American Association for the Advancement of Science, who discussed in a most

engaging and interesting manner the theme "Science and Higher Learning." Following Dr. Caldwell's pleasing address, came the event of the evening, namely, the presidential address, on the topic, "Modern Medicine—the Crossroads of the Social and Physical Sciences," by President Charles A. Doan. This address is, we believe, a noteworthy contribution to scientific literature and should receive wide-spread publication.

One must be impressed by the wide range and variety of scientific subjects covered by the 159 papers presented in the several sectional meetings on Friday afternoon and on Saturday; the meeting of three sections, namely, Zoology (A), Medical Sciences (D) and Chemistry (H), ran into Saturday afternoon owing to the large number of papers.

WILLIAM H. ALEXANDER,
Secretary

SPECIAL ARTICLES

THE SIGNIFICANCE OF THE ADRENALS FOR ADAPTATION TO MINERAL METABOLISM

RECENTLY Selye[1] has discussed the significance of the adrenals for adaptation. Briefly stated, he found that the removal of the adrenals increased the severity of the reaction produced in rats after exposure to variable surrounding temperature, excessive muscular exercise and toxic doses of various drugs. He found that rats became adapted to these stimuli, and after subsequent removal of the adrenals a severe reaction did not occur as a result of such treatment or exposure. Selye was of the opinion that the essential changes take place in the peripheral tissues and that the adrenal gland is involved merely in increasing resistance.

He assumed that "the symptoms of the alarm reaction are mainly due to the liberation from the tissue of some toxic metabolite (possibly histamine or some physiologically similar compound)," and finally pointed out that the changes which have been noted after adrenalectomy, such as circulatory disturbances, hypoglycemia, changes in concentration of sodium and potassium in the blood serum, deficiency in phosphorylation or increase in nonprotein nitrogen, all of which have been considered to be primary changes, are, in fact, symptoms of, rather than the cause of, adrenal insufficiency.

We have studied the changes which occur after adrenalectomy and agree with the conclusions of Selye in so far as they pertain to the ability of the adrenalectomized animal to acquire a tolerance to withstand toxic agents which throw stress on the organism.

Somewhat more than a year ago we[2] reported the effect of potassium when administered to adrenalectomized dogs which were maintained without the use of cortin on a diet which contained large amounts of sodium chloride and sodium citrate. It was found that if a diet which contained only traces of potassium was given for several months the adrenalectomized dog became extraordinarily sensitive to potassium in the daily ration. As little as 500 mg would bring about a severe prostration closely simulating acute adrenal deficiency. This experiment has been repeated in many dogs, but we have found that if the amount of potassium in the daily food is slowly increased the animal acquires the ability to tolerate it and much larger amounts of potassium are required to bring about a toxic effect.

Similar results were obtained by sudden shifts in the content of sodium chloride in a diet which also contained small amounts of potassium. If the sodium chloride was suddenly reduced to a minimum, profound collapse would occur and death would follow within forty-eight hours.

During stimulation of muscles in adrenalectomized rats it has been observed over a period of two years that there was an increase of potassium in the blood serum and as failure approached the concentration of potassium would rise to between 30 and 40 mg per cent. The administration of thyroxine improved the efficiency of the muscle, but failure was brought about more promptly and in each case it was found that the increase in potassium was more precipitous in the presence of thyroxine.

The concentration of potassium in the serum of some adrenalectomized rats is between 40 and 50 mg per cent. These animals may be apparently in good condition. Other adrenalectomized rats have died with typical symptoms of insufficiency with a concentration of potassium in the blood serum which was 10 to 15 mg per cent. lower. The important factor appears to be whether the animal has been able to acquire a tolerance which will withstand these increased concentrations of potassium. If sufficient time is given adaptation can occur.

Evidence that the adrenal gland is directly involved in the defense reaction against thyroxine but only in a transient way is shown by the following experiment: A series of rats after unilateral enucleation of the adrenal were treated daily with 0.1 mg of thyroxine. There was a prompt and marked enlargement of the remaining adrenal gland. The increase in weight was more than 200 per cent. However, after six weeks a regression in the size of the gland occurred and even-

[1] Hans Selye, SCIENCE, 85: 247–248, March 5, 1937.
[2] W. D. Allers, H. W. Nilson and E. C. Kendall, *Proc. Staff Meet. Mayo Clinic,* 11: 283–288, April 29, 1936.

tually the weight returned to about normal, even though the administration of the same amount of thyroxine was continued. We interpret this as evidence that until the peripheral tissues could acquire a tolerance to the changes induced by thyroxine the adrenal gland was stimulated. After adaptation by the tissues the stimulus to the adrenal was removed.

We agree with Selye that the several changes observed after adrenalectomy are all symptoms of, rather than the primary cause of, the condition of insufficiency, but we do not agree that the primary change is an increase in histamine or similar substance. Rather it is the inability to resist sudden violent changes in the concentration or distribution of electrolytes, and we feel that potassium should be included as at least one of the "toxic metabolites" postulated by Selye.

Brief comment may be made on two points of Selye's note. Although he stressed the emergency action of the adrenal cortex it is now known that the cortex is essential for life with or without a stress on the animal. There is only one known treatment by which a normal condition can be maintained in an adrenalectomized animal without the use of cortin. This treatment is the use of an enormously high intake of sodium chloride with sodium citrate or bicarbonate and a minimal intake of potassium. It has not been shown that such treatment modifies in any way the detoxification of histamine or like substances.

In all the conditions given by Selye as suitable to produce the "alarm reaction" there is a rise in the concentration of potassium in the serum. Adaptation may not prevent a rise in the concentration of potassium, but it does permit the animal organism to withstand the effects of such an increase.

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THE DISAPPEARANCE OF INJECTED EPINEPHRINE IN THE ANIMAL BODY[1]

ALTHOUGH several hypotheses have been advanced by various authors to explain the rapid disappearance of epinephrine from the blood after injection, none of these theories have been proved adequate. The general belief held was that destruction occurred mainly in the liver. From the present work it appears that the liver can not assume the major rôle in the destruction of epinephrine, since ligation of the blood supply to that organ does not alter the pressor effect of the active principle. Similar experiments with the spleen and kidney indicated that these organs also play unimportant rôles. These findings are substantiated by the fact that nephrectomy does not retard the disappearance of the active principle from the blood.[2] Other theories have been advanced that the nerve endings in the walls of the blood vessels lose their sensitiveness under the influence of epinephrine and relax. However, the pressor effect may be maintained for a long time by a continuous flow of dilute epinephrine solution into the jugular vein. The blood can not actively destroy epinephrine during the short duration of the pressor effect, since it was found by the present workers that freshly drawn blood or a phosphate buffer (pH 7.3) containing 0.5 per cent. H_2O_2 oxidized only 25 per cent. of a solution of epinephrine (1:1000) when allowed to remain in contact for a period approximating the normal duration of physiological activity. Oxidized epinephrine has no effect on blood pressure.[3]

The period of existence of ephinephrine in the circulation has been studied by several investigators. It was believed that at least 75 per cent. of intravenously injected epinephrine disappeared within 15 seconds after injection and, when hypertension subsided, no trace of the drug could be further demonstrated.[4] Weiss and Harris[5] believed that epinephrine is still left in the circulation after the blood pressure returns to normal. These investigators showed this by allowing blood, from which epinephrine seemed to have disappeared, to flow into an artery which had been previously ligatured; a constriction was observed. This observation has been confirmed by the present workers in the following way: Several samples of blood were removed from the circulation of an anesthetized cat at various intervals during epinephrine hypertension, and the presence of the hormone tested on a contracting gut preparation. It was observed that epinephrine remained in the circulation in small quantities for three minutes after the blood pressure returned to normal.

A few experiments on the products of destruction of epinephrine in the animal body have been reported by other investigators. The results which were obtained could not be interpreted. Embden and Von Furth[6] fed epinephrine to a rabbit orally after sewing up the rectum, and afterwards isolated from its urine a yellow product. They were unable, however, to determine its structure or suggest any possible relation to the epinephrine molecule. In the present experiments,

[1] From the Departments of Chemistry and Physiology, University of Saskatchewan.

[2] M. A. Goldzieher, "The Adrenals." The Macmillan Company, 1929.

[3] S. S. Weinstein and R. J. Manning, *Proc. Soc. Exp. Biol. and Med.*, 32: 1096, 1935.

[4] M. A. Goldzieher, *loc. cit.*

[5] O. Weiss and J. Harris, *Pfluger's Archives*, 103: 510, 1904.

[6] E. Embden and O. Von Furth, *Beitr. Zeits. Chem. Physiol. Path.*, 421, 1904.

rabbits were kept on a strictly controlled diet for 48 hours prior to the injection of epinephrine, and the phenolic content of the urine was determined in a 24-hour specimen. An increase in phenolic substances was obtained after epinephrine injection equivalent to 80 per cent. of the injected drug. A portion of the urine was acidified with acetic acid and allowed to stand for 48 hours, filtered, hydrolyzed by NaOH and concentrated under reduced pressure. The residue was extracted several times with 90 per cent. alcohol, and the extract reduced to dryness. The dark brown mass was extracted with ether. Upon evaporating the ether extract, a small quantity of crystalline material was obtained which gave characteristic tests for protocatechuic acid. The amount of material isolated was too small for combustion analysis. It would appear highly probable that protocatechuic acid may be an end product of epinephrine, since injected protocatechuic acid is excreted partly unchanged and partly as an ethereal sulfate.[7] Furthermore, Dakin[8] showed that phenyl serine and phenyl-glyceric acid are oxidized to benzoic acid and that p-hydroxy proprionic acid is oxidized to p-hydroxy benzoic acid. Comparing these structures with that of epinephrine, it is conceivable that a similar oxidation process might take place in the animal body yielding protocatechuic acid.

As an alternative hypothesis for the rapid disappearance of epinephrine from the blood, the following may be suggested from a critical consideration of the present findings; epinephrine is not destroyed by the blood nor to any significant extent by specific organs, but passes rapidly through the capillaries into the tissues, where it is oxidized to a physiologically inactive substance, possibly protocatechuic acid.

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MENINGOCOCCUS INFECTION OF THE CHICK EMBRYO[1]

GOODPASTURE and Anderson[2] have recently reported on the use of the chick embryo in the study of infections by various types of bacteria. They followed the technique previously described by Goodpasture and Buddingh[3] for the cultivation of vaccinia virus. This method offers a distinct advantage in that the behavior of infectious agents can be studied *in vivo* in a uniform sterile living culture medium. Observations on some of the phenomena of invasion and the earlier stages in the pathogenesis of various infections can be made with comparative ease and simplicity. Furthermore, the possibility of cultivating microorganisms which heretofore have been maintained with difficulty on artificial media or in laboratory animals presents itself.

In this communication we wish to report our findings on the cultivation of the *Micrococcus meningitidis* by this method.

A pure culture possessing all the staining and morphological characteristics of *Micrococcus meningitidis* was obtained directly from the spinal fluid of a patient with the typical clinical picture of cerebrospinal meningitis. Fermentation reactions were typical; it was agglutinated by a polyvalent antimeningococcus serum and the Type I monovalent serum (Gordon's classification) in dilutions of 1–100. No agglutination took place in normal horse serum.

The microorganism from the first culture obtained directly from the spinal fluid was inoculated onto the chorio-allantoic membrane of chick embryos twelve days old. A platinum loopful of the 18-hour blood agar slant culture was used as inoculum. At the end of 24 hours the majority of the embryos had died from the infection. In the remaining ones, Gram-negative diplococci in large numbers, both intra- and extracellular, could be demonstrated by smears made from the membranal exudate. Transfers by a platinum loopful of membranal exudate to fresh 11- or 12-day-old embryos have been made every 24 hours. The purity of the culture has been controlled by stained smears and inoculation of the membranal exudate on blood agar slants. Agglutination and fermentation reactions have been set up at frequent intervals. In this manner the strain has been passed through 100 serial transfers in the chick embryo without loss of its type specificity.

Throughout this period of investigation the infection has been uniformly lethal for the chick embryo. Death usually occurred 24 to 48 hours after inoculation. Cultures from the heart's blood of the embryo were usually positive for the meningococcus, indicating that, besides infection of the membrane, the embryo itself is also invaded.

A histological study of the lesion in the chorio-allantoic membrane and the chick embryo was undertaken. Twenty-four- and 48-hour membranal lesions and embryos were fixed in Zenker's (10 per cent. acetic acid) and embedded in paraffin. Sections were stained with hematoxylin and eosin and by Giemsa's method to demonstrate microorganisms.

Grossly the membranal lesion is not very striking. Twenty-four hours following inoculation there is slight cloudiness and swelling flecked with small streaks and patches of hemorrhage. Microscopically,

[7] E. Baumann, *Zeits. physiol. Chem.*, 1: 263, 1877.
[8] H. D. Dakin, "Oxidation and Reduction in the Animal Body," Longmans, Green and Company, 1922.
[1] Aided by a grant from the Division of Medical Sciences, Rockefeller Foundation.
[2] E. W. Goodpasture and K. Anderson, *Am. Jour. Path.*, 13: 149, 1937.
[3] E. W. Goodpasture and G. J. Buddingh, *Am. Jour. Hyg.*, 21: 319, 1935.

there is edema and a slight cellular infiltration with polymorphonuclears and monocytes of the mesoderm. Most striking are the numerous extensive hemorrhages within this layer. The ectodermal layer is usually covered with more or less cellular exudate in which the microorganism is present in large numbers. Necrosis of this layer does not occur except in those areas in which the blood supply in the underlying mesoderm is interfered with by hemorrhage or occlusion of the vessels. The most striking lesions are found in and around the blood vessels. The meningococcus invades the mesoderm and is found most abundantly in the areas of hemorrhage and in the lumen of the vessels. That a special affinity for the endothelial cells of the vessels obtains is evident from the fact that the microorganism is usually found in great numbers on the surface of these cells, often forming a complete collar around the inner surface of the vessel. It does not apparently grow intracellularly. Swelling and necrosis of vascular endothelium, with subsequent hemorrhage or thrombosis of the smaller vessels, result. The endodermal layer of the membrane is not greatly affected by the infection.

Within the embryo proper the microorganism produces lesions, particularly in the heart, meninges, kidneys and skin. All the lesions are vascular in origin and are evidently initiated by the lodging of the microorganism on the endothelium of the capillaries, with a resulting hemorrhage or thrombosis. In the heart numerous scattered foci of necrosis are found around small vessels and capillaries in which the diplococci can be demonstrated in close association with the endothelial cells. The meninges and choroid plexus show small areas of hemorrhage from small vessels in and around which numerous typical microorganisms can be found. The small capillaries of the kidney glomeruli are usually plugged with diplococci, so much so that an entire glomerulus often appears as a deep blue staining mass. In the skin and subcutaneous tissue hemorrhages are particularly frequent. The microorganisms are found here in abundance, growing on endothelial cells and among the escaped red blood cells. Vascular lesions of this type are occasionally observed in striated muscle, bone marrow and submucous tissues of the pharynx. In a few cases where multiplication of the microorganism within the embryo is particularly abundant the Kupffer cells of the liver are loaded with them.

Although these findings do not warrant any definite conclusion as to the pathogenesis of the earlier stages in the infection with the *Micrococcus meningitidis* in the human, it is well recognized that the purulent meningitis found at autopsy is an end stage in a disease which in its earlier stages is characterized by numerous pathological changes elsewhere in the body. The presence of the meningococci in the blood stream, sometimes as a chronic bacteremia, and the commonly recognized purpuric hemorrhages in the skin from which the microorganisms have been recovered by many observers indicate that the meninges may be secondarily invaded by meningococci transported by the blood stream.

In the experimental infection of the chick embryo the affinity of the meningococcus, once it has invaded the embryonic membrane, for the blood and vascular endothelium is the most striking feature. The ensuing lesions are all the direct result of this particular circumstance. The infection is essentially a septicemia.

Up to the present the study of infection by the *Micrococcus meningitidis* has been greatly hampered in that no suitable laboratory animal has been available in which the microorganism could be propagated in series away from its human host. Its relatively low pathogenicity has made necessary the use of exceptionally large doses in order to produce lethal effects in guinea pigs and mice. The clinical and pathological picture of cerebro-spinal meningitis has been obtained in monkeys only irregularly after direct inoculation of the central nervous system with large numbers of microorganisms.

Propagation of the *Micrococcus meningitidis* in the chick embryo is of additional interest because of the possibility of using this method for analyzing the effect of anti-sera and anti-toxins upon the infection. These and other immunological problems provide a wide field for investigation. They are now being studied, and our findings will be reported at a later date.

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ENVIRONMENTAL CONDITIONS INFLUENCING THE DEVELOPMENT OF TOMATO POCKETS OR PUFFS

THE condition known as tomato "pockets" or "puffs" is a serious disease or abnormal condition of the fruit of this crop in the Atlantic and Gulf Coast States, and frequently in California. This abnormal condition of the fruit is more prevalent in the mid-winter and early spring crops grown in Florida, and especially in the early spring crops grown in Mississippi and Texas. Frequently 15 per cent. of the total crop is lost in Texas and often individual growers will lose as much as 65 per cent. of their crop. The malady is also of frequent occurrence on tomato crops grown in greenhouses in the north.

During the past five years an intensive study of the

environmental factors, namely, soil moisture, relative proportion of mineral nutrients, temperature and length of day period, that may influence the development of tomato pockets has been made. A large amount of data has accumulated. These data represent a study of each individual plant, as to its daily and total transpiration rate and water requirement, and also, a study of the effects of sudden increases or decreases in soil moisture. The effects of sudden changes in temperature and in evaporation capacity of the air have also been studied. The detailed data are too extensive to present in tabular form in a résumé, so a summary of the major results is given.

The most important conditions within the plant and the associated factors that appeared to contribute to the pocketing of tomato fruits in these studies may be classified in three groups and are as follows:

(1) *No fertilization of ovules or typical parthenocarpy.* It should be recognized that the culture of tomatoes in the greenhouse under variable environmental conditions offers ideal conditions for producing pocketing of the fruit. Under ordinary circumstances pollen distribution is poor, but this was largely overcome by frequent agitation of the plants, by handling them in weighing to correct for water loss, in tagging the blossoms as they opened, in the tying of the plants to the stakes and in the taking of notes. In addition, the most prominent factors that contribute to sterility and parthenocarpy may be briefly noted: (a) abnormally long styles, a result of high temperatures; (b) slow germination of pollen tube, a result of low temperature; (c) slow growth rate of pollen tube, due to low temperature; (d) pollen abortion, due to low carbohydrate reserve, caused by high nitrogen, high soil moisture, high temperature and short-day light period; (e) ovule or embryo abortion, due to low nitrogen reserve, a result of low nitrogen, high soil moisture, high temperature and short-day light period. In these studies the many factors enumerated contributed strikingly to the development of pocketed fruit, especially when the plants were grown in the high and low temperature greenhouse units and when large amounts of nitrogen were applied.

(2) *Ovule of embryo abortion after normal fertilization.* The saturation or supersaturation of the soil appeared to cause marked changes in the normal metabolic, respiratory and transpiration activities of the plant, which in turn resulted in ovule or embryo abortion. Also, excessive drouth, accompanied by high transpiration, a condition that apparently results in endoxerosis, caused marked apparent changes in normal metabolic, respiratory and transpiration activities, and resulted in ovule and embryo abortion and the development of pockets.

(3) *Necrosis of vascular and placental tissue after fruit growth is well developed.* During any period of the growth of the plant, the saturation or supersaturation of the soil apparently stops almost entirely all transpiration; causes marked changes in color, the plants becoming chlorotic; and also interferes with the normal metabolic activities. These conditions apparently contribute largely to the appearance of necrosis of the vascular and placental tissues, which in turn leads to the development of pockets of the fruit of any age. Low soil moisture accompanied by high transpiration results in endoxerosis of the vascular and placental tissues. Sudden changes from optimum or high soil moisture to low soil moisture, accompanied by excessive transpiration, appeared to be the most drastic treatment of all that favored the development of pockets.

In these studies we are dealing with an environmental complex of many factors, as, for instance, soil moisture, soil nutrition, air temperature, light duration and the interrelation and interaction of these component factors, any one of which may become a limiting factor to normal plant growth, metabolic and respiratory activity, and thereby interfere with the normal development of tomato fruits. There is considerable suggested evidence that large amounts of superphosphate and only moderate amounts of nitrogen in the fertilizer reduce pockets by giving a nutritional balance conducive to more nearly normal seed development. The factors that can be observed and measured appear to bring about a general disturbance of the metabolism of the plant, causing a condition of suboxidation or endoxerosis; to affect the Co_2 and O_2 exchange, which, in turn, apparently leads to a visible necrosis of the vascular and placental tissues, thereby affecting ovule and embryo and placental development and normal fruit growth.

A more detailed report of this work is being prepared for publication at an early date.

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